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Summaries of Wildlife Research Findings

2006

Minnesota Department of Natural Resources
Division of Fish and Wildlife
Wildlife Populations and Research Unit

Minnesota
DEPARTMENT OF NATURAL RESOURCES

SUMMARIES OF WILDLIFE RESEARCH FINDINGS 2006

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MONITORING VEGETATION TO ASSESS CHANGES IN RELATION TO WHITE-TAILED DEER DENSITIES

Emily J. Dunbar and Marrett D. Grund

SUMMARY OF FINDINGS

High densities of white-tailed deer (*Odocoileus virginianus*) result in overbrowsing of forest vegetation. Intensive browsing can change forest ecosystem structure and composition by reducing palatable plant species and increasing unpalatable plant species. Past studies have examined differences in forest vegetation using exclosures between areas with no deer and high densities of deer. Few studies have investigated impacts of forest composition and structure by different or declining densities of deer. This study will examine impacts of declining deer density on forest vegetation at Itasca State Park. This report summarizes the first 2 years of data collection (2005-2006). Three plot arrays were established and sampled in 2005. Seven more plot arrays were added in 2006 and 10 arrays were sampled during summer and will be resampled in future years. Most plot arrays at Itasca State Park were unique in composition. Thus, results should not be compared among sites, but over time within each plot array. Overall, plot arrays were not highly diverse, averaging 2.3 using the Shannon-Weiner Index (0-5). Density and frequency of plant species was fairly low, with many species occurring in small numbers. Herbaceous reproduction was observed infrequently, although reproducing plants were taller on average than non-reproducing plants. Browsing mainly occurred on woody species rather than herbaceous species. Time series analyses will be used in future reports to determine changes in forest vegetation over time in individual plot arrays.

INTRODUCTION

In recent years, white-tailed deer populations reached high densities in many areas of Minnesota. Overabundant deer generate a variety of problems for both humans and forest ecosystems (Cote et al. 2004). Intensive deer browsing, resulting in reduced regeneration or even exclusion of some plant species, directly affects the distribution and richness of both understory and overstory forest vegetation (Rooney 2001) and could impact Minnesota's sustainable forest management certification. Alterations in plant populations may lead to a variety of changes in community structure including increased populations of unpalatable or browse-resilient species, the elimination of preferred woody and herbaceous species, and a decrease in resources for other wildlife (Horsley et al. 2003, Rooney and Waller 2003). Over time, intensive deer browsing can cause a forest ecosystem to succeed to an alternate state, characterized by unpalatable tree species and a ground layer of ferns, grasses, and sedges (Horsley et al. 2003).

Past studies examined differences in forest community structure between no deer inside exclosures and high densities of deer outside exclosures (Wisdom et al. 2006). Few studies investigated changes in forest structure with differing deer densities (Horsley et al. 2003, Tremblay et al. 2006) or declining deer densities. This study will assess impacts of deer browsing on forest vegetation and changes in vegetation due to a declining deer population in Itasca State Park in northwestern Minnesota. In 2005, Itasca State Park was selected as a study area for an alternative deer management research project. Antler-point restriction regulations were implemented during the regular firearms season. Alternative deer management was proposed to reduce deer densities. Our goal was to measure and monitor ecosystem-level effects caused by overabundant deer at Itasca State Park. Our secondary goal was to develop a forest vegetation monitoring protocol that could be used in other areas of Minnesota.

OBJECTIVES

- To determine the impacts of deer browsing at Itasca State Park;
- To assess changes in forest vegetation due to a declining deer population at Itasca State Park; and
- Develop a forest vegetation monitoring protocol for use in Minnesota.

METHODS

Vegetation sampling was conducted at Itasca State Park, in northwestern Minnesota, during July 2005 and 2006. A 16 x 16 grid was placed in the center of the park using Geographical Information Systems (GIS). Three plot arrays were selected in 2005 and 7 additional plot arrays were selected in 2006 (Figure 1) using a random number generator. Thus, we collected data from 10 plot arrays in 2006. Each sampling plot array contained a 50 x 50m (2500-m^2) plot and 5, 1-m^2 subplots. Plots were permanently marked with 0.6-m pieces of rebar at the center, at the corners of the 2500-m^2 sampling plot, and at a pair of diagonal corners of each 1-m^2 subplot (Figure 2).

Data were recorded from each 1-m^2 subplot and 2 m radius plot at the corners of the 2500-m^2 plot, and transects originating at each subplot. We intend to collect data annually at the arrays for at least 5 years. In each 1-m^2 subplot, all woody and herbaceous species (< 2.54 dbh and < 1.5-m tall) were identified and counted. Percent cover of each plant species was recorded using Daubenmire cover classes (Daubenmire 1959). Heights of woody or herbaceous plants were also recorded. We also recorded percent cover of bryophytes and lichens, tree seedlings, rock, and litter. Litter depth was measured and recorded using a meter stick at the center of each subplot.

Photographs were taken above each subplot and also in each cardinal direction to measure forest structure. At each corner of the 2500-m^2 plot, all trees and shrubs (> 1.5-m tall and/or between 2.54 and 12.7 cm dbh) within a 2-m radius of the permanent marker were identified to species, and height and dbh recorded. Percent overstory canopy was estimated using a spherical densitometer at the centers of subplots and a Graphical Resource Solutions densitometer (GRS) at 5, 5-m intervals along transects in each cardinal direction from subplot centers.

Slope, aspect, topographic position, and visual evidence of natural disturbance history (fire scars, insect/disease infestation, blow downs, etc.) were recorded for each sampling plot array. Abiotic differences can lead to differing plant compositions and subsequently, vary deer usage within forest ecosystems. If abiotic differences exist between the plot arrays, results will be compared on an individual array basis, rather than across arrays. To determine if the plot arrays were similar in plant species composition, Renkonen Similarity Index (RSI) was used. This index is robust in regards to sample size and species diversity and is one of the top quantitative similarity coefficients available to ecologists (Wolda 1981). The index ranges from zero (no similarity) to 100 (complete similarity) (Wolda 1981). The index was calculated by transforming number of plants for each species into percentages, using the following formula;

$$P = \Sigma_i \text{ minimum } (p_{1i}, p_{2i})$$

where P = Percentage similarity between sample 1 and 2

p_{1i} = Percentage of species *i* in community sample 1

p_{2i} = Percentage of species *i* in community sample 2

RSI was calculated using the subplots, 2-m radius plots, and overstory canopy along transects.

Plot arrays in 2005 and 2006 were measured for diversity using Shannon-Wiener function. Shannon-Wiener index is sensitive to changes in rare species in a community and ranges from zero (no diversity) to 5 (high diversity) (Peet 1974). The index was calculated using the following formula:

$$H' = -\Sigma_{i=1} (p_i)(\log_2 p_i)$$

where H' = Index of species diversity

p_i = Proportion of total sample belonging to *i*th species

Shannon-Wiener function of diversity was calculated using the subplots, 2-m radius plots, and overstory canopy along transects.

Density and frequency of plant species were calculated in the subplots and 2-m radius plots for both years. Frequency of the overstory canopy plant species was also recorded in both years. Estimates of forest horizontal cover were obtained in each subplot using a cover board. Plant reproduction was sampled in subplots by the presence/absence of flowers or fruit of each plant (i.e. Canada mayflower (*Maianthemum canadense*). Browsing intensity was recorded for each plant in subplots and 2-m radius plots. Browsing intensity was ranked based on percent of stems browsed and height of plant:

1. Not Browsed – no visible browsing damage
2. Light – 0 to 25% of seedling stems are browsed
3. Moderate – 25 - 50% of stems are browsed
4. Heavy - more than 50% of stems are browsed and the plant is severely hedged, but it is taller than 15 cm
5. Severely browsed – no seedlings of the species within the plot are >15 cm tall and seedlings are severely hedged

RESULTS AND DISCUSSION

A total of 42 plant species were recorded and 949 individual plants were sampled in 3 plot arrays in 2005 In 2006, 71 plant species were recorded and 3,515 individual plants were sampled in the 10 plot arrays. Overall, 2006 RSI scores ranged from dissimilar (5) to somewhat similar (68). The mean RSI score was 30, suggesting there was little similarity among plot arrays (Table 1). In 2006, the most similar subplots were in plot arrays 3 and 10 (Table 1). The plant species composition within 2-m radius plots in 2005 was dissimilar. The similarity of the plant composition of the 2-m radius plots in 2006 ranged from very dissimilar (0) to highly similar (95). In 2006, the similarity of plant composition in the overstory canopy, recorded from transects of each subplot, ranged from 8 to 76. The most similar plot arrays with regards to overstory canopy were arrays 2 and 10. Sample sizes of overstory canopy data were too low in 2005 to calculate similarity.

Average Shannon-Weiner diversity score of plot arrays in 2006 was 2.31, which indicates moderate vegetative diversity. Plot array 5 was most diverse (2.85) and the least diverse plot array was 7 (1.61). Average Shannon-Weiner Index scores associated with subplots within plot arrays was 3.49 (range 2.78 – 3.91) in 2005 and 3.63 (range 1.93 – 4.25) in 2006. The average diversity of the 2-m radius plots within plot arrays during 2005 was 1.48 (range 0.88 – 2.00) and 1.10 (range 0.36 – 2.12) in 2006. The average diversity of the overstory canopy in plot arrays in 2006 was 2.19 (range 1.1 - 3.16). Sample sizes were too low in 2005 to calculate overstory diversity.

In 2005, Canada mayflower had the highest density (4.9 stems/m^2) in the subplots and the average plant density among subplots was 1.1 stems/m^2 (Table 2). Similar to 2005, we found that Canada mayflower had the highest density in subplots (6.4 stems/m^2) and the average plant density was 0.69 stems/m^2 in 2006 (Table 2). The most frequently observed plant

species in the subplots in 2005 was sedge (*Carex* spp.). In 2006, the most frequently observed species in the subplots was mountain ricegrass (*Oryzopsis asperfolia*) (Table 2). In the 2005 2-m radius plots, sugar maples (*Acer saccharum*) had highest density (1,393 stems/ha) and the average plant density in 2005 was 517 stems/ha (Table 3). The most frequently observed species was beaked hazelnut (*Corylus cornuta*) (Table 3). In the 2006 2-m radius plots beaked hazelnut had the highest density (1,971 stems/ha) the average density in 2006 was 513 stems/ha (Table 3). The most frequently encountered species in 2005 was ironwood (*Ostrya virginiana*) (Table 3). In overstory canopy, red pines (*Pinus resinosa*) were the most frequently sampled species in 2005 (Table 3). In 2006, the most frequently observed species in the overstory was aspen (*Populus* spp*.)*.

In 2005, the average horizontal cover was 53%. Plot array 1 had the highest horizontal cover (80%) and plot array 3 had the lowest horizontal cover (29%) (Table 1). In 2006, the average horizontal cover was also 53%. Plot array 6 had the highest horizontal cover (90%) and plot array 7 had the lowest horizontal cover (19%) (Table 1).

Plant reproduction was sampled in subplots by the presence/absence of flowers or fruit of each plant. In 2005, 5 plant species had plants that were in the reproductive stage; big-leaf aster (*Aster macrophyllus)*, downy yellow violet (*Viola pubescens)*, early meadow-rue (*Thalictrum dioicum)*, large-flowered bellwort (*Uvularia grandiflora*), and twisted stalk (*Streptopus lanceolatus*) (Table 4). Four of the 5 species had low flowering sample sizes ($n \leq 2$). The average height of bellwort flowering plants was 38.1 cm (n = 15) and the average height of non-flowering plants was 21.8 cm (n = 26) (Table 4). In 2006, 5 plant species had plants that were in the reproductive stage; bluebead lily (*Clintonia borealis*), Canada mayflower, large-flowered bellwort, jewelweed (*Impatiens capensis*), and twisted stalk (Table 4). Three of the 5 species had low flowering sample sizes ($n \leq 3$). The average height of flowering bellwort plants was 37.7 cm (n = 13) and non-flowering plants was 27.5 cm (n = 161) (Table 4). The average height of flowering Canada mayflower plants was 8.5 cm (n = 16) and non-flowering plants was 5.0 cm (n = 302) (Table 4).

Browsing intensity was measured in subplots and sapling plots. In 2005, we found that most browsing was concentrated on tree seedlings in the subplots. Most species browsed had small sample sizes (n<10) or had low browse intensity (<2.0). Species browsed that had browsing intensity greater than 2.0 included mountain maple (*A. spicatum)* and ironwood (Table 5). Mountain maple had an average browsing intensity of 2.6 (n=6) and ironwood had an average browsing intensity of 2.7 (n=7). In the 2-m radius plot, no species had an average browsing intensity >1.1. In 2006, species browsed in subplots that had higher browsing intensities (≥ 2.0) included aspen and choke cherry (*Prunus virginiana*) (Table 5). Aspen had an average browsing intensity of 2.9 (n=28) and choke cherry had an average browsing intensity of 2.0 (n=4) (Table 5). In the 2-m radius plots, mountain maple, choke cherry, and red elm (*Ulmus rubra*) had browsing intensities > 2.0 (Table 5). Mountain maple had an average browsing intensity of 2.1 (n=20), choke cherry had a browsing intensity of 3.0 (n=1), and red elm had an average browsing intensity of 2.0 (n=2) (Table 5).

Due to time constraints, we reported frequency data and other descriptive statistics available to summarize the data collection thus far. Time series models will be used in future analyses to determine changes in forest vegetation and to account for differences in plant composition between plot arrays. We believe times series analysis models will facilitate determining “indicator” plant species that may increase in abundance and distribution under lower deer densities.

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Table 1. Similarity and diversity of plots sampled at Itasca State Park, Minnesota, July 2005, 2006.

Year	Plot array	Area sampled	RSI score[a]	Diversity	% Horizontal[b] cover
2005	1	Subplot	28 (2)	3.91	80
		2 m radius	20 (2)	2	
	2	Subplot	31 (3)	2.78	50
		2 m radius	14 (3)	1.57	
	3	Subplot	46 (1)	3.79	29
		2 m radius	32 (1)	0.88	
2006	1	Subplot	64 (8)	3.97	82
		2 m radius	72 (10)	1.55	
		Transects	47 (8)	2.65	
	2	Subplot	46 (7)	3.19	35
		2 m radius	90 (7)	1.37	
		Transects	76 (10)	1.9	
	3	Subplot	71 (10)	3.64	35
		2 m radius	19 (9)	0.84	
		Transects	53 (5)	2.58	
	4	Subplot	49 (6)	4.25	62
		2 m radius	95 (8)	0.81	
		Transects	66 (9)	2.35	
	5	Subplot	54 (1,3)	3.9	46
		2 m radius	57 (2)	1.5	
		Transects	53 (3)	3.16	
	6	Subplot	60 (1)	3.66	90
		2 m radius	80 (8)	0.83	
		Transects	47 (2)	1.37	
	7	Subplot	46 (2)	1.93	19
		2 m radius	90 (2)	0.88	
		Transects	47 (5)	2.01	
	8	Subplot	64 (1)	4.21	53
		2 m radius	95 (4)	0.72	
		Transects	61 (4)	2.5	
	9	Subplot	49 (1)	3.95	40
		2 m radius	43 (1)	2.12	
		Transects	66 (4)	2.32	
	10	Subplot	71 (3)	3.56	69
		2 m radius	72 (1)	0.36	
		Transects	76 (10)	1.1	

[a] RSI score = highest score for the area sampled and corresponding plot array
[b] % Horizontal cover = average cover for plot array

Table 2. Density and frequency of plant species sampled in subplots at Itasca State Park, Minnesota, July 2005, 2006.

Species	Common name	2005 Density[a]	2005 Frequency[b]	2005 Density[a]	2005 Frequency[b]
Acer rubrum	Red maple	0.93	0.53	0.92	0.20
Acer saccharum	Sugar maple	3.80	0.53	4.42	0.40
Acer spicatum	Mountain maple	0.40	0.13	0.58	0.22
Actaea rubra	Red baneberry			0.02	0.02
Amelanchier	Juneberry spp.			0.12	0.06
Amphicarpa bracteata	Hog-peanut	0.13	0.07	0.78	0.14
Anemone canadensis	Canada anemone			0.02	0.02
Anemone cylindrica	Thimbleweed				
Anemone quinquefolia	Wood anemone	0.13	0.07	1.26	0.06
Apocynum androsaemifolium	Spreading dogbane			0.08	0.04
Aralia nudicaulis	Wild sarassparilla	0.47	0.27	0.84	0.42
Aralia racemosa	American spikenard	0.27	0.07		
Arisaema triphyllum	Jack in the pulpit			0.28	0.02
Asarum canadense	Wild ginger			0.48	0.14
Aster macrophyllus	Big-leaf aster	4.80	0.47	4.42	0.62
Athyrium felix-femina	Lady fern	0.27	0.07	0.18	0.06
Betula papyrifera	Paper birch			0.04	0.02
Carex	Sedge spp.	4.67	0.67		
Caulophyllum thalictroides	Blue cohosh			0.02	0.02
Circea alpine	Enchanted nightshade			0.46	0.06
Clintonia borealis	Bluebead lily	0.87	0.13	0.60	0.20
Cornus canadensis	Bunchberry			0.16	0.02
Cornus	Dogwood spp.			0.30	0.14
Corylus americana	American hazelnut	0.33	0.07	0.06	0.02
Corylus cornuta	Beaked hazelnut	2.07	0.47	1.26	0.44
Dirca palustris	Leatherwood			0.10	0.04
Dryopteris carthusiana	Spinulose woodfern			0.06	0.04
Equisetum arvense	Horsetail fern	0.47	0.07	0.28	0.06
Fragaria	Wild strawberry spp.	1.33	0.20	2.48	0.50
Fraxinus nigra	Black ash			0.38	0.20
Fraxinus pennsylvanica	Green ash			0.06	0.04
Galium boreale	Northern bedstraw			0.02	0.02
Galium triflorum	Sweet-scented bedstraw			0.14	0.08
Gymnocarpium dyropteris	Oak fern			0.06	0.02
Hepatica americana	Liverleaf	0.13	0.07	1.14	0.18
Impatiens capensis	Jewelweed			0.20	0.02
Lathyrus ochroleucus	Pale vetchling			0.02	0.02
Lathyrus venosus	Woodland vetch			0.28	0.18
Mainthemum canadense	Canada mayflower	4.93	0.47	6.36	0.58
Matteuccia struthiopteris	Ostrich fern			0.34	0.12
Oryzopsis asperfolia	Mountain rice grass	0.93	0.33	3.80	0.66
Osmorhiza claytonii	Sweet cicley	0.73	0.20	0.70	0.24
Ostrya virginiana	Ironwood	0.47	0.20	0.16	0.08
Parthenocissus vitacea	Woodbine			0.02	0.02
Picea glauca	White spruce			0.02	0.02
Polystichum acrostichoides	Christmas fern	0.07	0.07	0.20	0.04
Populus tremuloides	Trembling aspen	0.07	0.07		
Populus	Aspen spp.			0.56	0.04
Prunus viginiana	Choke cherry			0.08	0.02
Pteridium aquilinum	Bracken fern	0.87	0.33	0.74	0.26
Quercus macrocarpa	Bur oak			0.13	0.08
Quercus rubra	Red oak	0.33	0.20	0.06	0.06
Ribes	Gooseberry spp.			0.22	0.08
Rubus acridens	Red raspberry	3.13	0.33	1.42	0.40
Rubus allegheniensis	Common blackberry	0.73	0.20	0.50	0.20
Rubus pubescens	Dwarf red blackberry			0.02	0.02
Sanicula canadensis	Black snakeroot			0.02	0.02
Sanicula marilandica	Maryland sanicle			0.04	0.02

Table 2. continued.

Smilacina racemosa	False Solomon's seal			0.02	0.02
Solidago	Goldenrod spp.	0.07	0.07		
Streptopus lanceolatus	Twisted stalk	3.53	0.40	2.00	0.48
Taraxacum	Dandelion spp.			0.02	0.02
Thalictrum dioicum	Early meadow-rue	1.33	0.33	1.44	0.46
Tilia americana	American basswood			0.04	0.02
Toxicodendron rydbergii	Posion ivy	0.07	0.07		
Trientalis borealis	Star flower	0.27	0.07	0.06	0.06
Triillium	Trillium spp.			0.18	0.06
Ulmus rubra	Red elm			0.10	0.04
Uvularia grandiflora	Large-flowered bellwort	2.73	0.53	3.52	0.58
Uvularia sessilifolia	Sessile-leaved bellwort			1.00	0.26
Vaccinium angustifolium	Lowbush blueberry	0.07	0.07	0.46	0.12
Vicia americana	American vetch			0.02	0.02
Viola	Wild violet spp.	0.07	0.13	0.50	0.12
Viola pubescens	Downy yellow violet	0.13	0.07		

[a] density reported as stem/m^2

[b] frequency reported as number of plots with plant present/total number of plots

Table 3. Density and frequency of plant species in 2 m radius plots and frequency of plant species on transects at Itasca State Park, Minnesota, July 2005, 2006.

		2005			2006		
Species	Common name	Sapling density[a]	Sapling frequency[b]	Canopy frequency[c]	Sapling density[a]	Sapling frequency[b]	Canopy frequency[c]
Acer rubrum	Red maple	1062	0.200	0.003			0.024
Acer saccharum	Sugar maple	1393	0.333	0.093	557	0.600	0.119
Acer spicatum	Mountain maple				378	0.267	0.001
Betula papyrifera	Paper birch	199	0.067	0.063			0.093
Corylus cornuta	Beaked hazelnut	1261	0.400		1971	0.600	
Fraxinus nigra	Black ash				239	0.400	0.114
Fraxinus pennsylvanica	Green ash						0.026
Fraxinus	Ash spp.	199	0.133				
Ostrya virginiana	Ironwood	331	0.133	0.047	438	0.867	0.037
Picea glauca	White spruce			0.003			
Pinus resinosa	Red pine			0.130			0.056
Pinus strobes	White pine						0.019
Populus tremuloides	Trembling aspen	66	0.067		916	0.600	
Populus grandidentata	Big-toothed aspen	531	0.133			0.133	
Populus spp.	Aspen spp.			0.087			0.283
Prunus viginiana	Choke cherry				20	0.067	
Quercus macrocarpa	Bur oak	66	0.067		60	0.133	0.035
Quercus rubra	Red oak						0.037
Quercus	Oak spp.			0.063			
Rubus allegheniensis	Common blackberry	66	0.067				
Tilia Americana	American basswood						0.062
Ulmus rubra	Red elm				40	0.133	0.008

[a] density reported as stems/ha

[b] frequency reported as number of plots with plant present/total number of plots

[c] frequency reported as number of points on transect with plant present/total number of points

Table 4. Plant reproduction in subplots sampled at Itasca State Park, Minnesota, July 2005-2006.

Species	Common name	Flowering?	N	2005 height (cm)	N	2006 height (cm)
Aster macrophyllus	Big-leaf aster	Yes	1	24.00		
		No	71	12.24		
Clintonia borealis	Bluebead lily	Yes			1	27.00
		No			29	17.97
Impatiens capensis	Jewelweed	Yes			1	50.00
		No			9	15.56
Mainthemum canadense	Canada mayflower	Yes			16	8.47
		No			302	5.03
Thalictrum dioicum	Early meadow-rue	Yes	1	50.00		
		No	19	33.42		
Uvularia grandiflora	Large-flowered bellwort	Yes	15	38.13	13	37.69
		No	26	21.80	161	27.46
Streptopus lanceolatus	Twisted stalk	Yes	2	32.00	3	41.33
		No	51	14.94	97	15.81
Viola pubescens	Downy yellow violet	Yes	2	24.00		
		No	0	0.00		

Table 5. Browsing intensity of plants sampled in subplots and 2 m radius plots at Itasca State Park, Minnesota, July 2005, 2006.

Species	Common name	2005 subplot	2006 subplot	2 m radius
Acer spicatum	Mountain maple	2.3 (6)[a]		2.1 (20)
Ostrya virginiana	Ironwood	2.7 (7)		
Populus	Aspen spp.		2.9 (28)	
Prunus viginiana	Choke cherry		2.0 (4)	3.0 (1)
Ulmus rubra	Red elm			2.0 (2)

[a] = sample size

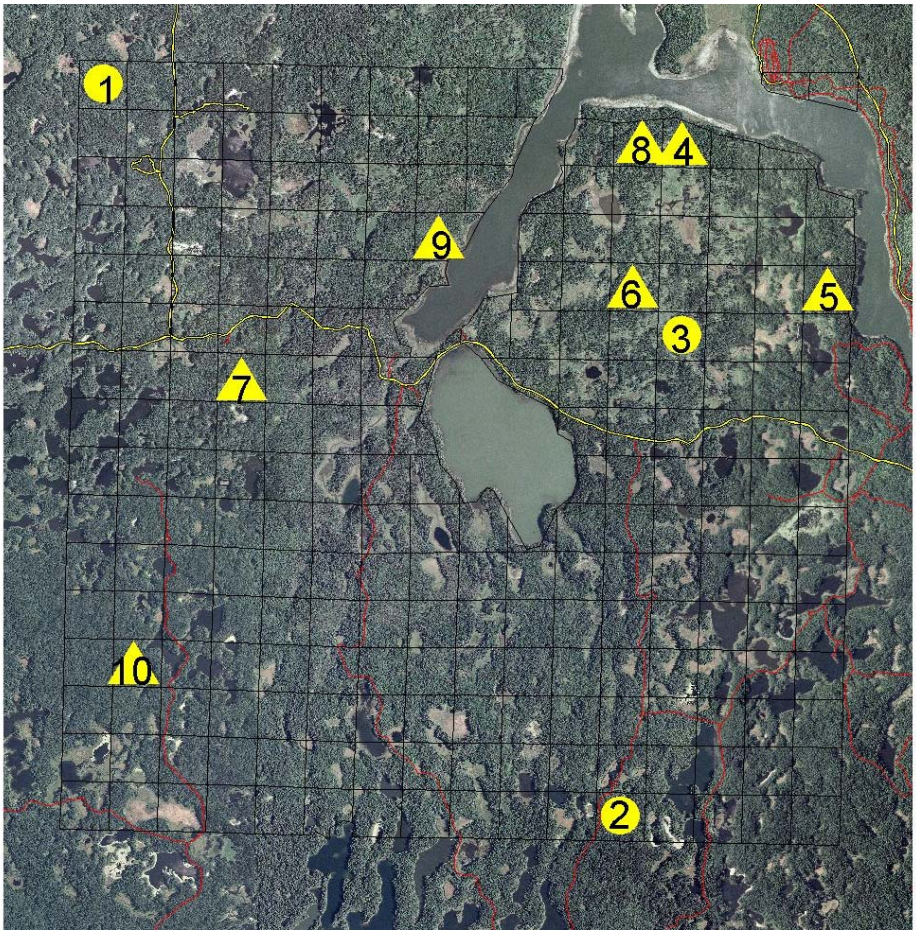

Figure 1. Plot arrays sampled at Itasca State Park, Minnesota, July 2005, 2006.